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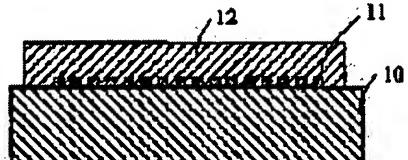
(72)Inventor : ISOBE ATSUSHI

## (54) ELASTIC BOUNDARY WAVE DEVICE

### (57)Abstract:

PURPOSE: To make a temperature characteristic excellent, to reduce insertion loss and to make productivity excellent by forming a SiO film on a  $\theta^\circ$  rotation Y-cut tantalic acid lithium single crystal substrate and defining the thickness of  $\theta$  and SiO<sub>2</sub> films as a specified condition.

CONSTITUTION: In the SiO<sub>2</sub> film 12 thickness dependency of the propagation speed of the elastic boundary wave BAW in a SiO<sub>2</sub>/ $\theta^\circ$  rotation Y-cut Xpropagation tantalic acid lithium single crystal piezoelectric substrate, the SiO<sub>2</sub> film 12 thickness (h) is standardized by a BAW wavelength  $\lambda$  (electrode cycle) and a cut angle  $\theta$  is made  $100 < \theta < 124$  or  $128 < \theta < 150$ . Because the dispersion of transmission speed is proportional to the dispersion of a center frequency when products are mass-produced, the small change of propagation speed for the dispersion of the SiO<sub>2</sub> film thickness is significant to improve a good item ratio. When the BAW is used, as the SiO<sub>2</sub> film is thickened by any  $\theta$ , the change of propagation speed becomes small. When the dispersion of the film thickness at the time of the preparation of the SiO<sub>2</sub> film is 15%, the dispersion of the center frequency of products can be made below 0.15% by setting  $h/\lambda > 1$ . Therefore, a temperature characteristic is made excellent, insertion loss is reduced and productivity is made excellent.



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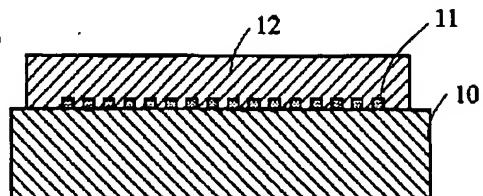
(54)【発明の名称】 弾性境界波装置

(57)【要約】

【目的】温度特性が良く、体積増大を伴う容器によるパッケージングを必要としない小型の弾性境界波装置を提供する。

【構成】温度特性の良い弾性境界波を強く励振するため、 $100 < \theta < 124$  または  $128 < \theta < 150$  であるような  $\theta$  回転Yカットタンタル酸リチウム単結晶圧電基板10上に弾性境界波波長換算膜厚  $h/\lambda$  が  $h/\lambda > 1$  であるシリコン酸化膜12を形成する。

図5



## 【特許請求の範囲】

【請求項1】角度 $\theta$ の回転Yカットタンタル酸リチウム単結晶圧電基板と、前記圧電基板の主表面に、少なくとも一対の電極指を有する電極周期入の樹型電極と、前記圧電基板及び前記樹型電極の上に、膜厚 $h$ のシリコン酸化膜を構成した弾性境界波装置において、前記圧電基板のカット角 $\theta$ を $100 < \theta < 124$ または $128 < \theta < 150$ とし、かつ $h/\lambda > 1$ としたことを特徴とする弾性境界波装置。

【請求項2】請求項1において、前記シリコン酸化膜の膜厚 $h$ と前記圧電基板のカット角 $\theta$ の間に、 $0.5 < 18 \times \lambda/h < 126$ の関係を有する弾性境界波装置。

【請求項3】請求項1において、 $130 < \theta < 145$ とした弾性境界波装置。

## 【発明の詳細な説明】

## 【0001】

【産業上の利用分野】本発明は、光、無線又はテレビIF（中間周波数）フィルタ等、小型化が要求される通信用フィルタに関する。

## 【0002】

【従来の技術】移動通信分野では、超小型のフィルタとして、弾性境界波装置が知られている。弾性境界波とは、特殊な条件の圧電単結晶基板上に、充分厚い非金属膜を形成することにより、基板と非金属膜との境界近傍に存在することができる弾性波である。このため、弾性境界波装置は体積増大をもたらす容器によるパッケージングを必要としない長所がある。

【0003】従来報告されている弾性境界波（BAW）は、シリコン酸化膜（以下 $\text{SiO}_2$ と略す） $/ 126$ 度回転YカットX伝搬タンタル酸リチウム単結晶圧電基板がある（例えば、アイ・イー・イー・イー、トランザクションズ オン ソニックスアンド ウルトラソニックス エス ユー 25巻 6号（1978年）第384頁から第389頁（IEEE Transactions on sonics and ultrasonics, SU-25, No.6, (1978) pp.384-389）。

## 【0004】

【発明が解決しようとする課題】 $\text{SiO}_2 / 126$ 度回転YカットX伝搬タンタル酸リチウム単結晶圧電基板は温度特性が悪い。このため、システムの仕様を満足できる弾性境界波装置を作製することは不可能であった。

【0005】本発明の目的は、このような従来の問題点を解決するため、温度特性の良いBAW装置を提供することである。

## 【0006】

【課題を解決するための手段】上記目的は、圧電基板に、 $100 < \theta < 124$ または $128 < \theta < 150$ である $\theta$ 度回転YカットX伝搬タンタル酸リチウム単結晶圧電基板を用い、 $\text{SiO}_2$ 膜の厚さを $h/\lambda > 1$ することにより達成できる。

【0007】ここで、 $\theta$ 度回転Yカットタンタル酸リチウム単結晶圧電基板とは、IRE標準の+Y軸からIRE標準の+Z軸方向に $\theta$ 度傾けた方向、またはIRE標準の-Y軸からIRE標準の-Z軸方向に $\theta$ 度傾けた方向に対して略垂直（誤差 $1^\circ$ 以内）であるようにタンタル酸リチウム結晶を切り出したタンタル酸リチウム単結晶圧電基板を意味する。また $h$ は $\text{SiO}_2$ 膜の厚さ、 $\lambda$ は樹型電極の周期を表す。

## 【0008】

【作用】上記構造の作用を調べるために、発明者らは $\text{SiO}_2 / \theta$ 度回転Yカットタンタル酸リチウム単結晶圧電基板を用いた弾性境界波素子を作製し、伝搬特性を調べた。作成した素子の電極構造は、電極周期 $4 \mu\text{m}$ 、対数10対、開口長 $110\lambda$ （ $\lambda$ ：電極周期）の二開口共振器である。また $\text{SiO}_2$ 膜はRFスパッタ法で作成した。その結果、以下のことが分かった。

【0009】①  $\theta$ にかかわらず、 $h/\lambda > 1$ のとき、急激に、弾性境界波装置の良品率が向上する。この様子を図1に示す。

【0010】②  $\text{SiO}_2 / 126$ 度回転YカットX伝搬タンタル酸リチウム単結晶圧電基板の構造で、 $\text{SiO}_2$ 膜を厚くしても、温度特性が良くならない。

【0011】③  $100 < \theta < 150$ でも、BAWは存在する。特に、 $100 < \theta < 124$ または $128 < \theta < 150$ では、 $\text{SiO}_2$ 膜の厚さを $h$ とすると、 $h/\lambda$ が1から3近傍で、極めて温度特性が良くなる。この様子を図2に示す。 $\theta$ 、 $h$ 、 $\lambda$ 間に $18 \times \lambda/h < 126$ の関係が成立するとき、遅延時間変化率の室温における1次温度係数 $T_{CD}$ の絶対値 $|T_{CD}|$ が最小値を示す。

【0012】④  $\theta = 138$ 近傍で、電気機械結合係数が最大になる。この様子を図3に示す。 $130 < \theta < 145$ で2%を超える。

【0013】以上のことから、 $100 < \theta < 124$ または $128 < \theta < 150$ のとき、 $h/\lambda$ を1から3の近傍にすることにより、 $|T_{CD}|$ が最小値を示すことが実験より分かった。このため、この条件を用いることにより、温度特性が良い弾性境界波装置を作成できる。

【0014】また $18 \times \lambda/h < 126$ とすることにより、いっそう温度特性が良い装置を作成できる。

【0015】また $130 < \theta < 145$ を用いることにより、最も大きな圧電効果が得られる。このため、損失の小さい弾性境界波装置を作ることができる。

【0016】また、 $\theta$ にかかわらず、 $h/\lambda > 1$ を用いることにより、弾性境界波装置の量産性を向上させることができる。

【0017】またBAWは、表面が非金属膜で保護されているため、電極の物理的、化学的変質が発生しない。

50 外部応力に対しても、非金属膜を介在する間接影響であ

るため、モルト剤で覆う、またシリコーン接着剤を非金属膜表面に塗っても特性の変化は極めて小さい。このため、体積を大きくする容器を用いたパッケージングを行う必要がなく、装置を小型化できる。

## 【0018】

【実施例】図1に本発明の1実施例として、 $SiO_2 / \theta^\circ$ 回転YカットX伝搬タンタル酸リチウム単結晶圧電基板におけるBAWの伝搬速度の $SiO_2$ 膜膜厚依存性を示す。 $SiO_2$ 膜厚 $h$ は、BAW波長 $\lambda$  (=電極周期)で規格化してある。また $SiO_2$ 膜はRFスパッタ法で作成した。作成した素子は、 $h/\lambda = 0.5, 1, 1.5, 2.0$ 、また $\theta = 100, 108, 114, 120, 126, 132, 138, 144, 150$ である。

【0019】製品を量産するとき、伝搬速度のバラツキは中心周波数のバラツキに比例するため、 $SiO_2$ 膜膜厚のバラツキに対して伝搬速度の変化が小さいことは、良品率向上に対して極めて重要な問題である。BAWを用いた場合、いずれの $\theta$ でも $SiO_2$ 膜を厚くするにつれて、伝搬速度の変化率が小さくなる。本発明によれば、 $SiO_2$ 膜作成時の膜厚のバラツキを±5%とする<sup>10</sup>と、 $h/\lambda > 1$ にすることにより、製品の中心周波数バラツキを0.15%以下にできる。

【0020】図2に $SiO_2 / \theta^\circ$ 回転YカットX伝搬タンタル酸リチウム単結晶圧電基板におけるBAWの温度特性を示す。縦軸は|TCD|である。

【0021】 $100 < \theta < 124$ と $128 < \theta < 150$ に必ず|TCD|が最小になる $\theta$ が存在する。 $SiO_2$ 膜が厚くなるにつれ、この $\theta$ は共に126度に漸近する。なお126度は完全なBAWであるため、 $SiO_2$ 膜が厚くしても、|TCD|はゼロにならぬ、一定値<sup>20</sup>に漸近する。測定値を内挿することにより、|TCD|が最小になる $\theta$ と $h/\lambda$ の関係を調べた結果、 $18 \times \lambda / h / |\theta - 126| = 1$ であった。

【0022】 $SiO_2$ 膜は、作成方法が異なると、弹性特性が変化することが知られている。特に、CVD法では、ガスソースの混合比を変えることで、SiとOの比が変化させることができ(通称 $SiO_x$ 膜と表すが、ここではこれを含めて、 $SiO_2$ 膜と表記する)、温度特性が大きく変化することが知られている。このため、RFスパッタ法以外に、常圧CVD法、プラズマCVD法により検討した。用いた圧電基板の $\theta$ は144度、 $SiO_2$ 膜の膜厚 $h/\lambda$ は0.5~1である。

【0023】その結果、常圧CVD法を用いた場合、 $h/\lambda = 0.8 \sim 0.96$ と、RFスパッタ法より多少小さい値で|TCD|が最小になった。プラズマCVD法を用いた場合、 $h/\lambda = 0.5 \sim 0.9$ と、RFスパッタ法よりかなり小さい値で|TCD|が最小になった。

【0024】以上の結果、 $0.5 < 18 \times \lambda / h / |\theta - 126| < 1$ の関係を有する場合、上記いずれかの手法により、|TCD|を最小にできることが分かる。<sup>30</sup>

本発明によれば、上記 $\theta$ 、 $h$ 、 $\lambda$ の関係を有することにより、|TCD|が小さい、つまり温度特性の優れた弹性境界波装置を作ることができる。

【0025】図3に $SiO_2 / \theta^\circ$ 回転YカットX伝搬タンタル酸リチウム単結晶圧電基板におけるBAWの電気機械結合係数( $k^2$ )を示す。 $130 < \theta < 145$ で2%を超える。本発明によれば、 $130 < \theta < 145$ を用いることにより、最も大きな圧電効果を得られる。このため、損失の小さい弹性境界波装置を作ることができる。

【0026】弹性波を用いた装置では、圧電基板の結晶の対称性から、 $\theta^\circ$ 回転Yカットと $\theta^\circ + 180^\circ$ 回転Yカットは全く等価である。このため、上記発明が、 $\theta^\circ + 180^\circ$ 回転Yカットタンタル酸リチウム単結晶圧電基板にも適用できることは明らかである。

【0027】図4、図5、図6に本発明の他の実施例を示す。図4は一開口共振器、図6は二開口共振器を示し、図5は断面図である。タンタル酸リチウム単結晶圧電基板10上に、 $SiO_2$ 膜12を形成している。タンタル酸リチウム単結晶圧電基板10と $SiO_2$ 膜12の間に、波長 $\lambda$ のBAWを励振する電極周期 $\lambda$ の櫛型電極11が存在する。

【0028】本発明によれば、 $SiO_2$ 膜12が櫛型電極11の保護膜として働くため、カンパッケージ等、体積を大きくするような容器によるパッケージを行う必要がない。

【0029】またBAWの伝搬方向をIRE標準のX軸方向にできるため、PFA (PowerFlow Angle: 位相速度と群速度の成す角度)をゼロにすることができる。このことはPFAを考えずに電極設計を行えるため、設計が容易に成る長所がある。

## 【0030】

【発明の効果】本発明によれば、 $\theta^\circ$ 回転Yカットタンタル酸リチウム単結晶圧電基板上に、 $SiO_2$ 膜を形成し、 $\theta$ 及び $SiO_2$ 膜の厚さを上記条件にすれば、温度特性が良く、挿入損失が小さく、量産性の優れた弹性境界波装置を作ることができる。

【0031】また $SiO_2$ 膜が櫛型電極の保護膜として働くため、体積増大を伴う容器によるパッケージングを必要としないため、超小型の弹性境界波装置が実現できる。このため、本発明の弹性境界波装置を各種通信分野のフィルタ等に適用することにより、モジュールの小型化、高性能化を実現することが可能になる。

## 【図面の簡単な説明】

【図1】 $SiO_2 / \theta^\circ$ 回転YカットX伝搬タンタル酸リチウム単結晶圧電基板における弹性境界波の伝搬速度の $SiO_2$ 膜膜厚依存性を示した特性図。

【図2】 $SiO_2 / \theta^\circ$ 回転YカットX伝搬タンタル酸リチウム単結晶圧電基板における弹性境界波の温度特性図。

【図3】 $S1O_2/\theta^\circ$ 回転YカットX伝搬タンタル酸リチウム単結晶圧電基板における弾性境界波の電気機械結合係数を示した特性図。

【図4】タンタル酸リチウム単結晶圧電基板上に、 $S1O_2$ 膜を形成し、その界面に櫛型電極を設けた一開口共振器の平面図。

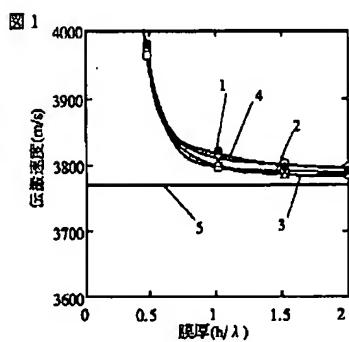
【図5】タンタル酸リチウム単結晶圧電基板上に、 $S1O_2$ 膜を形成し、その界面に櫛型電極を設けた一開口共振器の断面図。

【図6】タンタル酸リチウム単結晶圧電基板上に、 $S1O_2$ 膜を形成し、その界面に櫛型電極を設けた二開口共振器の平面図。

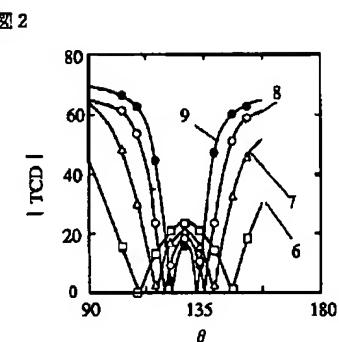
## 【符号の説明】

1… $\theta = 144$ の弾性境界波の伝搬速度、2… $\theta = 130$ の弾性境界波の伝搬速度、3… $\theta = 120$ の弾性境界波の伝搬速度、4… $\theta = 110$ の弾性境界波の伝搬速度、5…シミュレーションから求めた $S1O_2$ のパルク波の伝搬速度、6… $h/\lambda = 1$ の弾性境界波の|TCD|、8… $h/\lambda = 1.5$ の弾性境界波の|TCD|、9… $h/\lambda = 2.5$ の弾性境界波の|TCD|、10…タンタル酸リチウム単結晶圧電基板、11…櫛型電極、12… $S1O_2$ 膜。

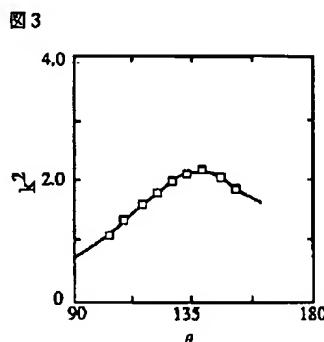
【図1】



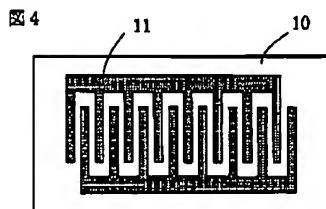
【図2】



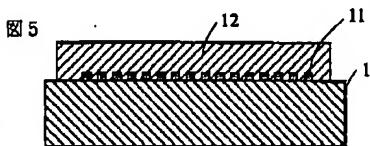
【図3】



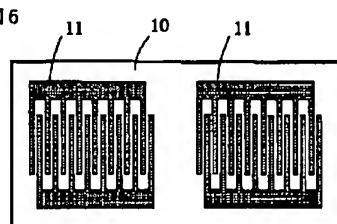
【図4】



【図5】



【図6】



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**CLAIMS**

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**[Claim(s)]**

[Claim 1] The rotation Y cut lithium tantalate single crystal piezo-electricity substrate of an include angle theta, and the tandem-type electrode of the electrode period lambda which has the electrode finger of a pair at least on the main front face of said piezo-electric substrate, Elastic boundary wave equipment characterized by having set the cut angle theta of said piezo-electric substrate to  $100 < \theta < 124$  or  $128 < \theta < 150$ , and being referred to as  $h/\lambda > 1$  on said piezo-electric substrate and said tandem-type electrode in the elastic boundary wave equipment which constituted the silicon oxide of Thickness h.

[Claim 2] It sets to claim 1 and is  $0.5 < 18x \lambda/h / |\theta - 126| < 1$  between the thickness h of said silicon oxide, and the cut angle theta of said piezo-electric substrate. Elastic boundary wave equipment which has relation.

[Claim 3] Elastic boundary wave equipment set to  $130 < \theta < 145$  in claim 1.

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[Translation done.]

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## DETAILED DESCRIPTION

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### [Detailed Description of the Invention]

[0001]

[Industrial Application] This invention relates to filters for a communication link with which a miniaturization is demanded, such as light, wireless, or a television IF (intermediate frequency) filter.

[0002]

[Description of the Prior Art] Elastic boundary wave equipment is known for the mobile communication field as a micro filter. An elastic boundary wave is an elastic wave which can exist near the boundary of a substrate and the nonmetal film by forming the sufficiently thick nonmetal film on the piezo-electric single crystal substrate of special conditions. For this reason, elastic boundary wave equipment has the advantage which does not need packaging with the container which brings about volume increase.

[0003] The elastic boundary wave (BAW) reported conventionally has silicon oxide (it omits the following SiO<sub>2</sub>) / 126-degree rotation Y cut X propagation lithium tantalate single crystal piezo-electricity substrate (for example, IEEE, transactions ON Sonics, and ultra Sonics S you from the 384th page to the 389th page of 25 s six No. (1978) (IEEE Transactions on sonics and ultrasonics, SU-25, No.6 (1978), pp.384-389)).

[0004]

[Problem(s) to be Solved by the Invention] A SiO<sub>2</sub>/126 degree rotation Y cut X propagation lithium tantalate single crystal piezo-electricity substrate has the bad temperature characteristic. For this reason, it was impossible to have produced

the elastic boundary wave equipment with which can be satisfied of the specification of a system.

[0005] The purpose of this invention is offering the good BAW equipment of the temperature characteristic in order to solve such a conventional trouble.

[0006]

[Means for Solving the Problem] The above-mentioned purpose can be attained by setting thickness of SiO<sub>2</sub> film to  $h/\lambda > 1$  to a piezo-electric substrate using a rotation Y cut X propagation lithium tantalate single crystal piezo-electricity substrate whenever [  $\theta$  / which is  $100^\circ < \theta < 124^\circ$  or  $128^\circ < \theta < 150^\circ$  ].

[0007] Here, a  $\theta^{**}$  rotation Y cut lithium tantalate single crystal piezo-electricity substrate means the lithium tantalate single crystal piezo-electricity substrate which cut down the lithium tantalate crystal to the direction  $\theta^{**}$  Leaned to standard +Z shaft orientations for IRE from standard + Y-axis for IRE, or the direction  $\theta^{**}$  Leaned to standard -Z shaft orientations for IRE from standard - Y-axis for IRE so that it might be an abbreviation perpendicular (less than 1 degree of errors). Moreover,  $h$  is SiO<sub>2</sub>. Membranous thickness and  $\lambda$  express the period of a tandem-type electrode.

[0008]

[Function] In order to investigate an operation of the above-mentioned structure, artificers produced the elastic boundary wave component which used SiO<sub>2</sub> /  $\theta^{**}$  rotation Y cut lithium tantalate single crystal piezo-electricity substrate, and investigated the propagation property. The electrode structures of the created component are the electrode period of 4 micrometers, ten pairs of logarithms, and the 2 opening resonator of opening length  $110\lambda$  ( $\lambda$ : electrode period). Moreover, SiO<sub>2</sub> The film was created by RF spatter. Consequently, the following things were understood.

[0009] \*\* Irrespective of  $\theta$ , the rate of an excellent article of elastic boundary wave equipment improves rapidly at the time of  $h/\lambda > 1$ . This situation is shown in drawing 1 .

[0010] \*\* At the structure of a SiO<sub>2</sub>/126 degree rotation Y cut X propagation lithium tantalate single crystal piezo-electricity substrate, it is SiO<sub>2</sub>. The temperature characteristic does not become good even if it thickens the film.

[0011] \*\* As for BAW,  $100 < \theta < 150$  exists. Especially, at  $100 < \theta < 124$  or  $128 < \theta < 150$ , it is SiO<sub>2</sub>. If membranous thickness is set to  $h$ , the temperature characteristic will become  $[h/\lambda]$  good extremely 1 to about three. This situation is shown in drawing 2. When the relation between  $18x\lambda/h / |\theta-126|=1$  is materialized between  $\theta$ ,  $h$ , and  $\lambda$ , absolute value  $|TCD|$  of the primary temperature coefficient TCD in the room temperature of time delay rate of change shows the minimum value.

[0012] \*\* An electromechanical coupling coefficient becomes max about  $\theta=138$ . This situation is shown in drawing 3. It exceeds 2% by  $130 < \theta < 145$ .

[0013] From the above thing, the experiment showed that  $|TCD|$  showed the minimum value by carrying out  $h/\lambda$  near 1 to 3 at the time of  $100 < \theta < 124$  or  $128 < \theta < 150$ . For this reason, the temperature characteristic can create good elastic boundary wave equipment by using this condition.

[0014] Moreover, by being referred to as  $18x\lambda/h / |\theta-126|=1$ , the temperature characteristic can create good equipment further.

[0015] Moreover, the biggest piezo-electric effect is acquired by using  $130 < \theta < 145$ . For this reason, the small elastic boundary wave equipment of loss can be made.

[0016] Moreover, the mass-production nature of elastic boundary wave equipment can be raised by using  $h/\lambda > 1$  irrespective of  $\theta$ .

[0017] Moreover, since the front face is protected by the nonmetal film, physical and chemical deterioration of an electrode does not generate BAW. Since it is the indirect effect which intervenes the nonmetal film also to external force, change of a property is very small even if it applies a wrap and silicone adhesives to a nonmetal film front face by the malt agent. For this reason, it is not necessary to perform packaging using the container which enlarges the volume, and equipment can be miniaturized.

[0018]

[Example] SiO<sub>2</sub> of the velocity of propagation [ in / as one example of this invention / to drawing 1 / a SiO<sub>2</sub>/theta<sup>\*\*</sup> rotation Y cut X propagation lithium tantalate single crystal piezo-electricity substrate ] of BAW A film thickness dependency is shown. SiO<sub>2</sub> Thickness  $h$  is standardized on the BAW wavelength  $\lambda$  (= electrode period). Moreover, SiO<sub>2</sub> The film was created by RF sputter. the created component --  $h/\lambda = 0.5, 1, \text{ and } 1.$  -- it is 5, 2.0 and theta= 100, and 108, 114, 120, 126 and 132,138,144,150.

[0019] Since the variation in velocity of propagation is proportional to the variation in center frequency when mass-producing a product, it is SiO<sub>2</sub>. It is a very important problem to the improvement in the rate of an excellent article that change of velocity of propagation is small to the variation in film thickness. Any theta is SiO<sub>2</sub> when BAW is used. The rate of change of velocity of propagation becomes small as the film is thickened. According to this invention, it is SiO<sub>2</sub>. When variation in the thickness of film creation time is made into \*\*5%, it is the center frequency variation of a product by making it  $h/\lambda > 1$  0.15% It is made to below.

[0020] The temperature characteristic of BAW in a SiO<sub>2</sub>/theta<sup>\*\*</sup> rotation Y cut X propagation lithium tantalate single crystal piezo-electricity substrate is shown in drawing 2 . An axis of ordinate is |TCD|.

[0021] theta from which |TCD| surely becomes min exists in  $100 < \theta < 124$  and  $128 < \theta < 150$ . SiO<sub>2</sub> It carries out asymptotic [ of this theta both ] to 126 degrees as the film becomes thick. In addition, since it is perfect BAW, 126 degrees is SiO<sub>2</sub>. If |TCD| is at zero even if the film thickens, it carries out asymptotic to \*\*\*\* and constant value. As a result of |TCD|'s investigating the relation between theta and  $h/\lambda$  it is unrelated to min by interpolating measured value, it was  $18x \lambda/h / |\theta - 126| = 1$ .

[0022] SiO<sub>2</sub> As for the film, it is known that elasticity will change if the creation approaches differ. Especially, it is known for the CVD method that the ratio of Si and O can make it change (it is written as SiO<sub>2</sub> film here including this although

expressed the common-name SiO<sub>x</sub> film), and the temperature characteristic will change a lot by changing the mixing ratio of the gas source. For this reason, it inquired by the ordinary pressure CVD method and the plasma-CVD method in addition to RF spatter. theta of the used piezo-electric substrate -- 144 degrees and SiO<sub>2</sub> membranous thickness h/lambda -- 0.5-1 it is .

[0023] Consequently, when an ordinary pressure CVD method was used, |TCD| was somewhat set to h/lambda =0.8-0.96 from RF spatter to min with the small value. When a plasma-CVD method was used, |TCD| became min with h/lambda =0.5-0.9 and a value quite smaller than RF spatter.

[0024] It is  $0.5 < 18x \lambda/h / |\theta - 126| < 1$  the above result. When it has relation, one technique of the above shows that |TCD| is made to min. According to this invention, by having the relation of Above theta, h, and lambda, |TCD| is small, that is, can make the elastic boundary wave equipment which was excellent in the temperature characteristic.

[0025] The electromechanical coupling coefficient (k<sub>2</sub>) of BAW in a SiO<sub>2</sub>/theta\*\* rotation Y cut X propagation lithium tantalate single crystal piezo-electricity substrate is shown in drawing 3 . It exceeds 2% by  $130 < \theta < 145$ . According to this invention, the biggest piezo-electric effect can be acquired by using  $130 < \theta < 145$ . For this reason, the small elastic boundary wave equipment of loss can be made.

[0026] With the equipment using an elastic wave, the symmetric property of the crystal of a piezo-electric substrate to the theta\*\* rotation Y cut and the theta\*\*+180-degree rotation Y cut are completely equivalent. For this reason, the above-mentioned invention applicable also to a theta\*\*+180-degree rotation Y cut lithium tantalate single crystal piezo-electricity substrate is clear.

[0027] Other examples of this invention are shown in drawing 4 , drawing 5 , and drawing 6 . Drawing 4 shows a 1 opening resonator, drawing 6 shows a 2 opening resonator, and drawing 5 is a sectional view. On the lithium tantalate single crystal piezo-electricity substrate 10, it is SiO<sub>2</sub>. The film 12 is formed. The lithium tantalate single crystal piezo-electricity substrate 10 and SiO<sub>2</sub> Between

film 12, the tandem-type electrode 11 of the electrode period lambda which excites BAW of wavelength lambda exists.

[0028] According to this invention, it is SiO<sub>2</sub>. In order for the film 12 to work as a protective coat of the tandem-type electrode 11, it is not necessary to perform packages with a container which enlarges the volume, such as a can package.

[0029] Moreover, since the propagation direction of BAW is made to standard X shaft orientations for IRE, PFA (PowerFlow Angle: include angle which phase velocity and group velocity accomplish) can be made into zero. Since this can perform an electrode design, without considering PFA, it has the advantage of which a design consists easily.

[0030]

[Effect of the Invention] According to this invention, it is SiO<sub>2</sub> on a theta<sup>\*\*</sup> rotation Y cut lithium tantalate single crystal piezo-electricity substrate. The film is formed and it is theta and SiO<sub>2</sub>. If membranous thickness is made into the above-mentioned conditions, it is good, an insertion loss is small, and the temperature characteristic can make the elastic boundary wave equipment which was excellent in mass-production nature.

[0031] Moreover, SiO<sub>2</sub> Since packaging with the container accompanied by volume increase is not needed in order that the film may work as a protective coat of a tandem-type electrode, micro elastic boundary wave equipment is realizable. For this reason, it becomes possible by applying the elastic boundary wave equipment of this invention to the filter of the various communication link fields etc. to realize modular miniaturization and high performance-ization.

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## DESCRIPTION OF DRAWINGS

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### [Brief Description of the Drawings]

[Drawing 1] SiO<sub>2</sub> of the velocity of propagation of the elastic boundary wave in a SiO<sub>2</sub>/theta<sup>\*\*</sup> rotation Y cut X propagation lithium tantalate single crystal piezo-electricity substrate Property Fig. having shown the film thickness dependency.

[Drawing 2] The temperature profile of the elastic boundary wave in a SiO<sub>2</sub>/theta<sup>\*\*</sup> rotation Y cut X propagation lithium tantalate single crystal piezo-electricity substrate.

[Drawing 3] The property Fig. having shown the electromechanical coupling coefficient of the elastic boundary wave in a SiO<sub>2</sub>/theta<sup>\*\*</sup> rotation Y cut X propagation lithium tantalate single crystal piezo-electricity substrate.

[Drawing 4] On a lithium tantalate single crystal piezo-electricity substrate, it is SiO<sub>2</sub>. Top view of the 1 opening resonator which formed the film and prepared the tandem-type electrode in the interface.

[Drawing 5] On a lithium tantalate single crystal piezo-electricity substrate, it is SiO<sub>2</sub>. Sectional view of the 1 opening resonator which formed the film and prepared the tandem-type electrode in the interface.

[Drawing 6] On a lithium tantalate single crystal piezo-electricity substrate, it is SiO<sub>2</sub>. Top view of the 2 opening resonator which formed the film and prepared the tandem-type electrode in the interface.

### [Description of Notations]

1 -- The velocity of propagation of the elastic boundary wave of theta= 144, 2 -- Velocity of propagation of the elastic boundary wave of theta= 130, 3 -- The velocity of propagation of the elastic boundary wave of theta= 120, 4 -- Velocity

of propagation of the elastic boundary wave of theta= 110, 5 -- SiO<sub>2</sub> calculated from simulation Bulk wave propagation rate, |TCD| of the elastic boundary wave of 6 --  $h/\lambda = 1$ , 7 --  $h/\lambda = 1.5$  |TCD| of an elastic boundary wave, |TCD| of the elastic boundary wave of 8 --  $h/\lambda = 1$ , 9 --  $h/\lambda = 2.5$  |TCD| of an elastic boundary wave, 10 [ -- SiO<sub>2</sub> / Film. ] -- A lithium tantalate single crystal piezo-electricity substrate, 11 -- A tandem-type electrode, 12

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[Translation done.]

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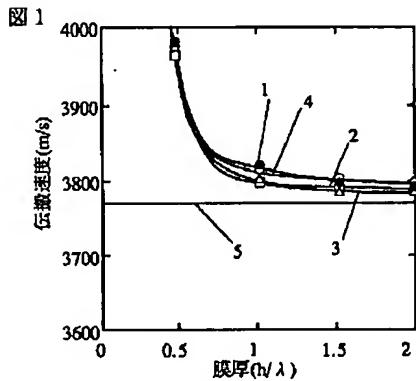
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DRAWINGS

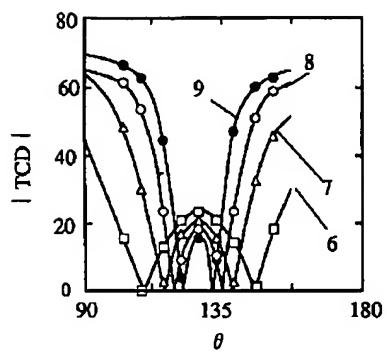
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[Drawing 1]



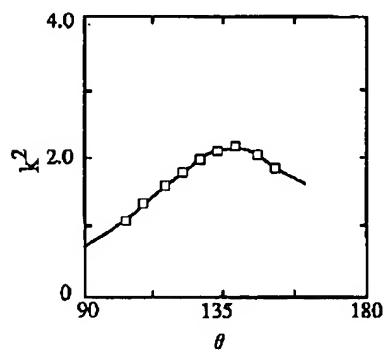
[Drawing 2]

図 2



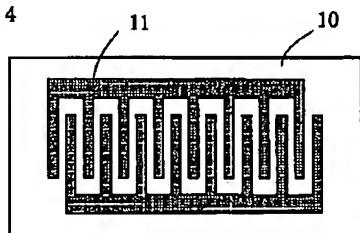
[Drawing 3]

図 3



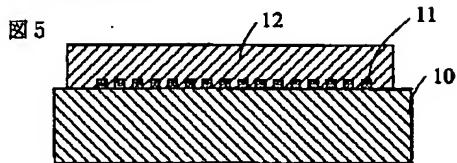
[Drawing 4]

図 4

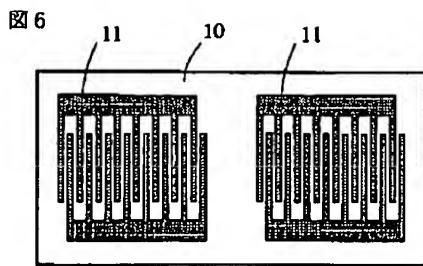


[Drawing 5]

図 5



[Drawing 6]



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[Translation done.]